Notebook, E-4298

This notebook was used by Edison during November 1904. There is one additional entry from 1927. It contains notes and drawings relating to experiments with alkaline storage batteries that may have been transcribed from other notebooks. The entries describe numbered groups of experimental cells to be constructed and indicate the results of tests performed on them. The groups of cells differ in their construction and chemical composition. Included are groups made with molasses, glucose, potassium cyanate, and various preparations of nickel hydroxide. Other groups are distinguished by differing treatments of cups and grids and differing charge or discharge conditions. The entry from 1927 is a brief note about a 1904 entry pertaining to iodides in electrolytes. The notebook contains 300 numbered pages; many pages are blank.

Battery Experiments Nov 26 1904

Group cups heated red in vapor sulphur or H_2S passed over to form Sulphide on cups for soaking hot in 33% or 21

Group Extra-heavy plated soaked 33% hot in plating use CP plating solution & CP Nickel anode —

Group unplated Cups

Group all CP Nickel —

Soak Group: Regs in CP (Stick) Alcoholic KOH, 33% hot 48 h
" " " Merecks CP KOH, "
" " KOH from Sulphate "
Group made from C all cups Reg KOH, "
" " Reversed Reg KOH "
Group Reg cups Reg Ni Mallinckrodt Reg KOH, "
" " in NaOH from mallinckrodt 33%
" " " " 21%
Make group 5000 perfo - soaked 48 hours 33 —
" " Reversed "
" " " Changed 15 h 100 in 33% 150 7 hr
" " Not reversed " "

Powder to pass 50 mesh reduce by Hydrogen then act on it Electrically with KOH Containing Hypo this will keep particles from breaking & softening & work ok if pass theory ok —

Reduce Carbonate Ni by Hydrogen then full pass by precipitation & drying with C full. use low temp to keep Ni Crul from shrinking

Nov 29 1904

Make some NiOH by precipitating Sulphate by the po in right proportions then 2 pressures KOH, warm get out basic salts wash & dry—

Open one of the 24 hour Grosse grisha - see how black also if packed close, first soak water #

Boil some NiOH/2 6 hours at 33% 250 Fahr then drain off 33% wash with water (well washed) dry and make group Reg run also group for reversal - group for 120 hours. Use CP Nickel dish bumped up notice after drying of bulk no scaling, 842. dry mix all the above —

Group Regs Changed 33% little NH Carb in solution,

Molasses after thorough cooking mix with 1/2 gram Ni by Hydrogen then dry - put in cups, press — soak — The Ni gives chemical gas coming out,

for 4 hours soak in 33% hot, group of 2 gram pockets 2.2 2.5 2.8 —

Run Reg group curve in 21% long charge 1st then 3 3/4 hour on groups of 2. 2.2 2.5 2.8 3.2 see if output per gram on short chgs is better for thin cups —

Because gas makes the glucose Ni

Tell gas a Duplicate the 5% NH_4CO_3 dry mix of old book

Hereafter used reversed perforations, Rogers make a hot,

Take the twisted 157 - cups soak in water till Koff out then dry & put in new cups when one of it comes back —

Take another 157 Cups reverse in 21% 150 Fahr & Run Reg after that soak in hot water then dry & then put back in 21% chlg & dvslg Reg - if goes thru OK should run

See if I have a group of green soaked in 33 hot 24 hours & then chlg 150 Fahr in 33% 100 rate & then put in 21% chlg 15 h 200 dvslg 100 -

Reverse the bad aluminum Nickel segment a strip hot Change Koff. & Run Reg one of reversing will make it OK —

When the Malaccca group is run first reverse then in 21% warm - say 125 Fahr for 15 hours 100 rate, to get out malaccca - old book showed that glycerine reversed was OK & when not reversed was bad.-

Should try some green that have been dehydrated to yellow point but not too far, use without grafite soak 48 h 33% hot. ~~also~~

Try make a group crimped and corrugated without putting scarcely any pressure on mix think 1½ tons pressure on mix closes up everything & chlorate gets in & closes what little passages left for gas exit & we get terrible polgin Many possibly Corrugate Cups first —

Make 24 to hold 5 cups each mount on rubber tops for Cell tests —

Try the soaked green cups after 4 runs for heavy discharge rate also 2 runs not going below 120 V

Try group where grid saturated with solution of NH_4 & NH_4Cl_2 to slightly dissolve the surface of pieces of mix — dry then put in KOH, & precipitate, then soak water & dry — Run Reg —
Vary the amount & Time of soaking The theory without it will be ok as the NaOH particles together & when Chgd will call be a conductor,
Can try powdered green oxide base of Cu get a Coherent mix this way — Thus a cementing like action of H_2SO_4 on PbO to cement it together, There may be a grand deal in this way of manipulating the Ni mix in the pocket,

Have Warren take a charged num of Ni & Read V 1" apart, 7/8 3/4 5/8 1/2 3/8 1/4 1/8 1/16 to get chgd — also vary the chgd of Cells —

Get a way of getting our KOH free of Alumina

This looking together The green (OH) = by a solvent like NH4 – presence of a NH4 salt. may be just the thing wanted possibly the iron in we can get 330 to V without graphite by soaking hot in 33% so that it softens the $Ni(OH)_2$ & makes a better Ni Contact, – may Explosion only acid issues with NH_4CO_2 gives gramming much good results. Try different methods of $Ni(OH)_2$

Perhaps reg $Ni(OH)_2$ 50 or even 30 mesh coned be mixed with a minor $Ni(OH)_2$ + corrugated then dried + would run good – ditto Reg Mix –

Make groups Reg Ni to be run with green Ni Hg in now —

Reg cups [illegible]

Looking together try weak ~~[illegible]~~ NiCl $NiNO_3$ $NiSO_4$ Nacetate dry + then KOH warm, soak H_2O – etc.

4 Ni in 33% 175 fahr Stick KOH, Reversed 100 rate 15 hours then run in 21%
Average 3.2 500 to V.

Reversing hot or cold in 33% 400 rate gives high capacity 600 To 620
for 1st run in 21% but capacity gradually goes down
there is really no gain

4209 5 Ni Chgd in 33% 175 fahr with 4 grams Silicate Soda in the 33%
100 rate 15 hours. then put in KOH 21% steadily High at 1st —
gradually goes down 6th Run 475, 50, 343, 412, 347 } apparently swelling made bad contact

There is only normal swelling when charged in 33% or
discharged in 21% the great swellings only from
discharge in 33%

4214 Reversed in 33% 150 7. 15 h 100 — 5 grms Bismuth Hydrox No gain

All manipulations of reversing or chg in 33% hot or cold
failure —

4254 to 4269 Reg Ni soaked in 33% on hot plate 140 fahr 48 h 508, 72 506, 96 500, 120 494 — no gain
Run Reg — 21 —

4274 — Same as above but only green Ni hydrox no graf —
Apparently Soaking in 33% hot does lots of good as we
get as high as 323 To Volt on 3.2 grms — 48 hours soak
appears 62 best, shorter or longer dont do as well —

4299 = 5 Ni mix heated 225 fahr before use in pockets for 2 hours.
pockets heated 4 hours 225 each put in cell with 1% KOH.
chgd 15 h 200 dis 100, 2nd run in 21%
1st 113 — 2nd 504 — 3rd 512 — not much gain
Drop but run in 2% on 1st run — 1st 274 2nd 496 - 3rd 516 -

" "	4%	"	1	379	504	520
	8	"	1	448	501	521
	16	"	1	490	513	501
	32		1	463	492	490

4364
4450 Alumina is fatal to the nickel, does not apparently affect the iron — for some unknown reason considerable wing comes out consider little at one end than 1/4 of 1 end than 1/2 of pocket — this should be investigated

4369. Charging in 33% and lamp & discharg in 21%
only gives 440, 437, 438, 438 } a loss —

4374 5th mi
Charged hot 150 in 21% against mi strip then
chgd in 21% normal lamp against strip & then put with
chgd mine & discharg 1st C 325, 495, 415, 593, 583 } 12th dis 502, 576, 493, 478, 405. no gain

There are various irregularities in working hot in 33% (10) chg pt times get high capacity & very low cap some group after 1/2 dis chgs chgs This is Evidently due to bad crump & well —

4404 — A Dry mix which gives good results, 548 on 7th run a dup made long time after Neg — There is great deal in manipulation of the mix & state of packets.

A test of several cups having mix passed out showed spring back — Center 10 Edge 1.2
See No 2 book at end —

4458 A group charged in 33% Containing Aluminum & then taken out & recharged & run in 21% didn't show effect of Aluminum very bad, gives about 400 to V. Think bad effect is in discharg

4463 5 cells Continuing 3 grams KCy - (cant say if on each cell or the whole) chg'd under Reg. gave good results.
gave 1st 33 - 2nd 514 3rd 548 5th 523 14th 530
Evidently KCy is good but further Experts show it frailey - should be investigated -

4468 group with Hyposulphite Soda is pretty good
13th run 515

Iodide of Potassium in the KOH is fatal to it -

496 to Volt seems to be normal capacity for a regular under conditions from 4000 to 7000 -

4424 group reversed perfo chg'd 21% 15 h 100 rate 150 Temp then chg'd Cold goes about 520 on 9th run -
Think there is not much gain, Experts so far dont show that reversed perfo are much advantage

4473 group gone bad by Iodide Sodium down to 65 to ✓
Reversed hot, went on 4th run 385 345 405 - So reversals do partly restore capacity - probably if done in best manner Cond be nearly restored

Alumina Models that have gone bad Cannot be restored by reversing - in fact they grow worse

KOH, 21% in which filter paper has been boiled does no harm.

ditto filter paper + 2 grms pp Mercuric oxide. appears to do no harm –

I think Hyposulphite helps a bad cell.
Cyanide of Potassium nearly restores the Capacity of many pockets from a bad cell –
Think if done right they might be fully restored – See 4493 – to freaky

1 gram of aluminum metal dissolved in each cell – from reg cannot on 9th run cells to give only average of 22 to V.

4504 Zinc dissolved – Electrolyte in small quantity does no harm.

4509 Lead is bad but only probably because it deposits all over –

4519 Cups plated thinly with Iron 1st run 495 14th run 477 = Iron) & considered bad – on long run

4524 Silver plated Cups 2nd run 523 11th 501 – possibly a little better than Reg for these runs –

4529 Cadmium Plated. 1st 510 11th run 504 apparently OK – strange – why

4534 Copper plated 1st 498 – 2nd 507 10th 515 – 13th 503 – apparently OK but no quin

4594 Regs with Iron having no mercury 1st 485 — 15th 485 —
Seems to be very cap + constant.

4599 Same as above but chgd in 33 150° —
12th run 530. Extra Capacity given by 33% Condemned after dropping a Certain amount possibly Endurance tests will show these Non Mercuric runs will be more constant,

4919 Iron made anodes previously in 33% + put with Reg No in 21% no gain —
+ [illegible] by [illegible] in [illegible]

4619 Cells filled with all Carb K 25% Neg — go to V

4624 Group run in 5% KOH 15 K_2CO_3 — 1st 475 — 12th 405 —
4629 10% KOH 10% " 1st 496 — 12th 490
4634 15 KOH 5% " 1 448 12th 462
These are very irregular, think due to bad pockets,

4660 Reg cups 3.2 dipped 3 minutes in our Reg No Sulfate Solution dried on plate then soaked 120 hours in 33% + put to reg cells shows irregular runs from day to day but gives 510 to 525 To V — Many to something in it of properly manipulated —

4665 Reg No with Hg + Zn at bottom gave about 500 — somewhat irregular from day to day

467 No with one side float allen Convex no gain Except a slight gain from 1st To 6th run
1st 495 6th 506 —

4680 Group dipped 3 minutes in Ammonia Chloride Ammonia
4685 Solution in which Nickel hypox is dissolved afterwards soaked 156 hours in 33%

Run Reg 1st 477
2 502
3 517
4 543
5 545
9 513 – I want 1st 462 but average above

Evidently by manipulation there is something in this

4703 Use of smooth Die only – Rinsed two at Not good 7th run 415 to V

4713 Citrate of Potash does not appear to do harm

Reversing heat 150 in 5% KOH. on Regs does no good
4727 Rinsing. Chg in 5% KOH hot. is better but loses + does no better than reg on 7th run to 1st 495
4732 a larger charge 32 hours does a little better, 512

Use of Stick Potash seems to tend to regularity
4765 1st 497 – 3rd 510 10th 489 –

4775 Cleaning inside of Cups with Emery paper does a little good – 4th 510 –

Running in Methyl Alcohol . 0 .
" 33% Sod Na Formate . 0 .

4792 A new nickel soaked 6 hours in Ethyl Alcohol shows good improvement, Evidently something dissolved out that hurt Conduct or acted as insulator — 1st 553 — 8th 557 — This is good — but I notice original Calliper is large than usual — may be mistake made it was due to more Ni in my subsequent Experiments shows alcohol, Benzole no improvement —

4797 Same as above but Benzol used 1st 544 8th 540 — This also shows abnormal large Center Calliper — No good — it was Extra Ni

4802 Juice from shavings of old juice rubber E 18 21% used — Cell — its about normal 3rd run
4807 Pkg ring rubber, about same shade better perhaps

4812 1 gram pp Magnesium hydroxide in each cell.
1st 485 — 6th 488 — no gain —

33% Borax —	"0"
33% Phos K	"8 to V"
30% Silicate Na	"0"
33 Acetate K	"0"

Group of Charged nickels put in Water which is changed many times till rust color in water appears indicating nearly all KOH out. Then put in KOH 21% Recharged This is an improvement 1st 524 4th 566 —
4837 *probably the NiO_2 goes to pieces, There may be swelling ? —

4842 No pressed flat, Rev. & perf — no smooth or Corrugated due used — 480 to V. not so good as Req

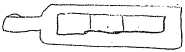
4847 Req Cups Extra heavy plotted at Phoenix Works 1st run 505 7th 522 — this seems to be an improvement

4852 Cells with juice of Bumbler separators about Req 508

4856 ditto with separators Cut from sheet, should better than Req 517 -

4861 ditto thin sheet rubber axles — 518 to V.

4871 Cup sliced across worse than Req 475

4876  3 cups as one

Little better than Req — 515

4881 Gelatin even in large quantity makes daily runs very irregular Thus 428 + 493 - 476 - 383 - 295 - 419 - 490 -

4896 Old C cups 1250 holes with our mix all req - goes less than Req 475 @ 480 to V

4901 Reversed perq C cups 485 to V.
4906 5000 holes. worse than Rey 460 @ 490
Reversed abt same

4924 Sulphate Paloish 2 grms to cell or 2 grms to the 5 cells Cambridge which — apparently does no harm —

4929 - Cups on crimped by a die that wears on Edges only. Rey — 367 to V

4934 Cyanate Paloish little worse than Rey 464 to V 20% Sol Cyanate 17 to V 4937

4944 Group ni Cane sugar seems do no harm.

4949 Tartrate Paloish seems do no harm

4954 New 5 to mch by Corrugtns

5 atmos press.		1st	334	10th	238
10	"	"	424	"	341
20	"	"	444	"	435
40	"		474		425
80	"		482		450
160	"		508		503
200			501	5th	511
250			471	5th	530
300			433	5th	529

poss hydraulic practical

Its doubtful if our presses at the Rly — would give an equivalent to 250 atmos pressure on other press — find out -

4993 -

Aluminum 500 milgms each cell -

	1st	7th
500	309	64
250	364	87
125	391	113
62	423	259
31	461	416
16	467	445
8	486	502

5028 Group - Glucose seems do no harm slight improvement 6th 506

5038 2 grms Acetone each cells

1st	143 -
2	287
3	357
4	421
5	422
6	440

Evidently improves but not

5043 Hypophorous acid - 2 grms each cell - about Reg 6th run

5048 fresh precip Carb Calcium about Reg 495

5053 " " Barium chloride better than Reg 510

5058 " " Magnesia Improvement 1st 522 - 7th 542

5063 Magnesia Hydroxide about Reg

Should judge from Iodide K
that Bromide K would be bad
Chloride K "

Iodide being worst Br K next
+ KCl least

Chlorides are certainly bad in Cells

Sept 1 1927

5068 Mn with Irons having no Mercury 21%
Containing Iodide Sodium –
5073 1st 377 2nd 264 3rd 191 4th 143 –
Hence the Iodine acts itself + not by Hg

5078 Same as above no Hg in Iron
by Aluminum in KOH.
5083 1st 379 2nd 246 – 3rd 182 4th 144

5138 Group 16 milgms Iodide K each cell 1st 471 6th 472
32 499 465
64 456 — 313
125 430 205
250 438 137
500 393 97

5168 Regs with Sluminate K 500 mg in each or all
Containing w/ hydrate cell Ring

5173 21% Sodium from Metallic –
1st 535 2nd 536 – 3rd 530 – 4th 520 6th 512

5178 Group Caustic Lime 10 grms each cell
+ 500 milg Aluminum – 230 to V mg
5183 – Magnesium powder + aluminum do 197 to V

5188 Extra strips put in cell & charged to deposit anything bad — Ng with 500 mlg Aluminum deposit take it out 203 to V

5194 Millons bases does not render Aluminum unnecessary — 260 to V

5199 On account of mess undeveloping when I cast for 250 milgms of Aluminum Cant say if its in each cell or all @ 50 mlg each cell —
With fresh pp Ba Carbonate,
1st 462 6th 390 — possibly Mor $BaCO_3$ would do it if al was small —

5212 glucose stops effects Aluminum but probably Aluminum never put in (Dep these)

5227 Sulphate K — another mistake —

5217 Ba hydrate about Rag 500 to V — 3 grms each cell

5232 Group with 2 grms Fluoride K or Na Seems improved cell — Dep —
525 to V

Stick KOH purified by Ca washed Ba little better than Rag I think

5241 Peroxide Hydrogen seems improves cell 515 to 520 —

5246 Red oxide Mercury dont help the Alumina
5251 green Nickel (OH)$_2$ " "

5261 Heating the KOH 21% in presence of powdered $Ni(OH)_2$ to 150° for 6 hours does no good to run of Reg.

5271. Alumina in 21% with any kind of perforations ~~steel~~ goes bad — also 10% KOH, al just as bad

5306 Ag_2O 2 gms each cell — not so good as Reg. 457

5311 3 gms flower Sulphur Each cell — No — am running 2½ suspension only

5316 5 pockets with a strip run in one cell, with 1 gram Aluminum — + then washed from all Reg cells — 1st 350 2nd 290

5321 Lump KOH, not treated with Ba about Reg —

5336 Calcium Sachrate no good to stop Alumina

5351 5 Reg mix 1 gram Al in 5 cells — 3 grms. KCy in 5 Cells — 1st 556 3rd 525
Evidently KCy can be made to moderate alumina — freely —

5356 ditto with Iron having no Hg
1st 560 3rd 525

5366 Cyanate of K dont stop alumina

5375 Ammonia is bad for Cells it acts on Hg not the Fe

Big Corrglns run in 33% dis in 33% sulph bad on low pressure but — gives low results. Even 300 almost 450 to ✓

5488 — Borax 3 grm — 5 cells abt Reg

5508 Chloride Hydrate. less than Reg 470
Carb Strontia abt Reg
" Cerium "

5533 Grains Soaked 6 hours Grain alcohol 21% with 3 grms KCy Each cell —
1st Run 575

5538 Same as above but with 9 grms ~~treated~~ same way
1st run 299 — ? ? Why

5553 21% 3 grms fresh $CaCO_3$ + 3 grms KCy Each cell
1st run 586?

Reg mix scived out 5 in group –

On 20	1st 508	4th 474	
40	508	488	Seems Great.
60	477	467	
80	471	450	
100	438	453	
120	384	250	
140	313	124	
160	335	217	
180	292	171	

Note!

Tried 2 grms KCy 100 cc KOH 21% on Ni_2O_3 made Chemically – dissolves very considerable Then possibly KCy cannot be used as it might in time soften or gassing would work the grid dangerously – KCy does not dissolve but very little of the $Ni(OH)_2$ – possibly its action in changing NiO_2 explains why get such good results,

In pockets from 9.660 battery which has been run about 2½ months + has lost 30% Capacity notice crystals which exactly resemble mercuric oxide – They are reduced by H_2O_2 to Hg leaving a white frame work of some unknown Element not dissolved by Hyposulfite, KCy Iodide + – probably Alumina – Some pockets have lots of these Crystals + some have none

I have not found any in changed Cups but only in Reversed Cups where all the Ni is nearly gone & the Crystals are in Contact with the Cups & yet are not reduced, this is strange if they are mercury – possibly they do not make Contact –

The Cups which have Lodged in cell after they have gone bad show on opening an iridescent peacock film all over the graphite –

There is no doubt but that there is considerable Alumina & Silica in the graphite used in the Mix all our Experiments are being made with, Also that Graphite Can be purified down to two tenths impurity mostly silica & iron The act of mixing breaks up the cleavage planes & exposes the impurities making them Especially obnoxious – As Alcohol & Benzol remove an exceedingly small trace of matter & yet improve the cell greatly it is a matter of importance to get rid of impurities in the Graphite – Not enough Al etc in anything in cell to account for loss of Capacity as per Dunn analysis –

Iwa finds in old Cells some Sulphide & some none – Evidently the rubber varies in the heat of Vulcanization & leaves the sulphur in different Conditions, some affected & Come out in the liquid & so oxidized to H_2SO_4 – I take this matter up with the Rubber people –

When nickels are fully charged & have then put in water & this charged often there comes a point where the polish is very weak and any poorly plated part of a cup or the frame commences to be rapidly attacked by local action between NiO_2 & the now forming a powerful electrolyt, this is not true of a discharged nickel hence there is a gradual loss of Capacity if the nickel — in 5% or more KOH — There is probably no action on acct of passivity or polarization yet it might be just as well on the cups to be sure of good plating & welding

In all experiments so far increased pressure on cups increases output & the increase seems to be entirely due to the Compressing effect to the smooth glass disc —

Cyanide of Hg in small quantity 100 to 200 mdy in 6 inch small cell where the now has no mercury is beneficial to output Contrary facts | due to Ni or Zn —

Charging cold in 33% 15 hours 100 rate
then pulling in 21% in 6 hours before chg
then chg 15 hours 200 rate disch 100- 1st 440 4th 438
Hence under above conditions Charging in 33%
Cold gives no increase of output.

3 grms water glass in 100 cc KOH 21% does a little
damage when Ni recovered 1507 in 33 - after chg 2nd run
average of group 4284 - That charged in 33% hot
gave average 597 2nd run - 5th run 508, 595, 473, 475